

Jefferson Lab Cryogenic Technology



Thomas Jefferson National Accelerator Facility



Jlab Cryogenic Systems Focus

- **Provide unsurpassed reliability and availability for 2.1K and 4K multi plant operation. (>99.5% experimental beam for combined accelerator plants with very long intervals between major maintenance plant shutdowns (5-7 years))**
- **Provide continuous technology advancement for 4K/2.1K helium cryogenics that reduces required manpower and utility use while increasing plant reliability and availability**
- **Share technology advancements with other DOE laboratories, research organizations and industry.**



Overview of JLab Cryo Plants

- **Four Cryogenic Plants (6 refrigerators, 5 have 24/365 operation)**

JLab plants and those designed by JLab (MSU and SNS) are designed for unattended operation. (major difference in staffing requirements and daily work focus compared to other laboratories)

- CHL(2.1K Central Helium Liquefier, largest operating 2K)**

- 1991, 4600W @2.1 K, 12KW @35K +10 g/s; 112,000 hrs ops;
- Supports CEBAF, FEL, Experimental Halls
- Will double in 2.1K capacity size for planned Jlab 12 GeV Upgrade

- ESR (15K/4K End Station Refrigerator, 1977 LBL)**

- 1993, 1500W @4K; 94,000 hrs operation
- Supports Experimental Halls A/B/C Spectrometers and Targets

- CTF (2.1K Cryogenic Test Facility)**

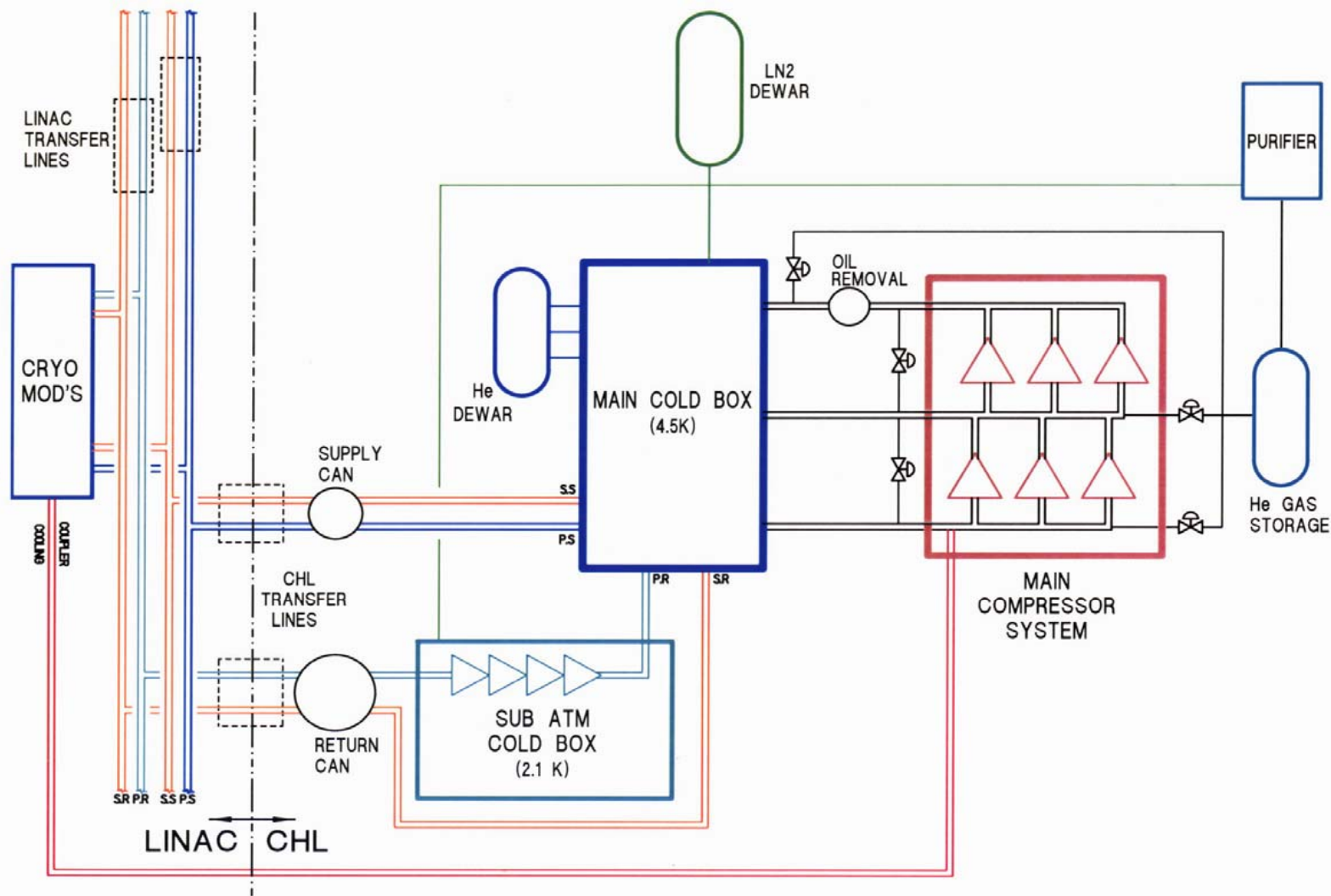
- 1989, 750W @4K with warm 2.1K vacuum pumping, >120,000 hrs operation
- Also has 65 L/hr CTI M2800 Liquefier and shield refrigerator
- Supports testing of cryomodules, cavities, and hall targets

- SBR (Stand-by Refrigerator, former uncompleted SSC)**

- 1998, 1650W @4K, 13000W @35K; 1150 hrs operation
- 4K Backup for CHL during scheduled maintenance every 5-7 years

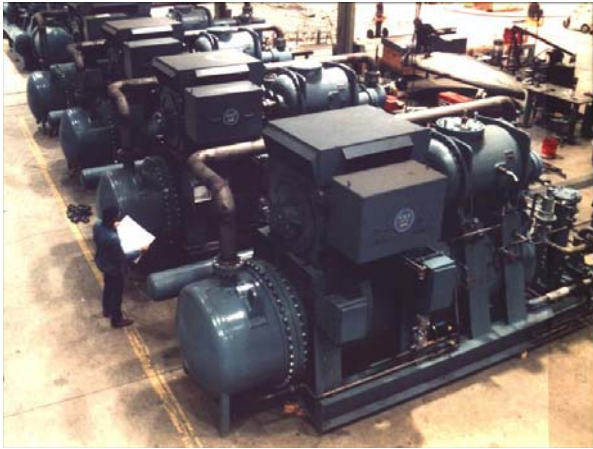


CHL 2K System Schematic



JLab 2.1K CHL Helium Plant

Helium Compressors



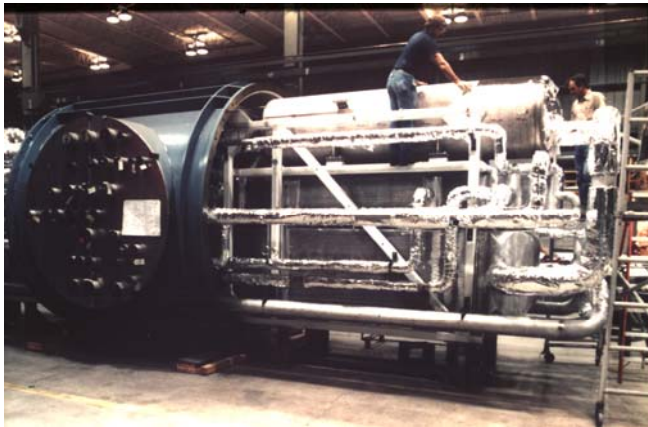
4K and 1st 2K Cold Box



JLab 2nd 2K Cold Box



4K Cold Box Internals



2K Cold Box Internals



Jlab Staff Experience

- **Engineering and Design**

- Merger of experienced commercial helium plant engineers and designers with experienced cryogenic laboratory engineers and technicians. Full support of process cycle design, mechanical, electrical, and instrumentation/controls engineering...not found in other labs. Key to bring plant operation needs and design closer.
- Group senior engineers and designers participated in vast majority of all of the operating 2.5K, 3.5K and 4K helium large scale plants designs for US labs in the last 30 years (BNL, LANL, SSC, SLAC, FERMI, SNS, ORNL, LLL, LBL, LANL, ANL, MSU, etc.) as well as commercial plants (Linde, Cities Service, Exxon, etc.)
- Is the most experienced large scale helium cryogenic plant design group currently in the US today
- Jlab 2K cold box design is into its 3rd generation, Four 2K cold compressor systems to date, 3 of which are JLab designed

Jlab Staff Experience

- **Technician Staff**

- Balanced experienced maintenance and fabrication staff in all technical areas**

- Rotating machinery (turbines, compressors, cold compressors, vacuum pumps)
 - Electrical Systems (120/208V, 480V, 4160V) power distribution and cryogenic utilization equipment)
 - Computer, PLC, Relay control, Cryo Instrumentation
 - Cryogenic Mechanical Fabrication (Transfer Lines, cold boxes, purifiers, oil removal, gas management, compressors)
 - High Vacuum Systems
 - Trained as operators



Cryogenic Technology Overview

- Cryogenic Technology strongly linked to SRF and Superconducting Magnets (Jlab Accelerator, Experimental Halls and FEL)
- Historically, Helium Cryogenic Technology has had to make order of magnitude jumps to meet the challenges for experimental needs. **Example: Jlab 2.1K, 235 g/s technology derived from previous 5 g/s technology of Torr-Supra. 2K operations place substantially different design criteria on the system**
- Jlab has further refined and advanced 2K and 4K plant design and operational technology since its initial plant commissioning of 1991. **This benefits both existing and future plants of all labs.**



JLab Cryogenic Advancements

- **Jlab Cryogenic Operations**

- **Automated plant control, very small operator staff**
- **Elimination of air and oil system contamination**
- **Plant Utility Reduction**
 - Power savings for Jlab CHL, 6.5Mw to 5.5Mw to 4.5Mw
 - JLab variable system pressure and gas management control technology (applicable for existing and new systems)
 - Patent Pending “Ganni Process Cycle” for substantial cost savings for new plant capital and operating cost. Serious Industry interest
 - Patent Disclosure for “Improved LN2 Pre-cooling Design for Helium Plants”, much less liquid nitrogen utility use
- **Increased time intervals between major maintenance**
 - Oil Removal System Maintenance; 5-7 yr to 10-12 yr
 - Main Compressor Overhauls; 45 K-hr to 72 K-hr
 - Refrigerator Shutdown Maintenance; Yearly to 5/7 yrs
- **Procedures and design features which allow continued accelerator 2K operations while isolating and servicing individual system components (cryomodules, magnets, targets)**



JLab Cryogenic Collaborations

— BNL: Multi-phase program, 3 years, 2002-2005

- RHIC refrigerator Power Reduction, 9.2 to 5.7 MW
- Plant Process Cycle Modeling for RHIC application
- Compressor Oil Migration Correction
- Automated Systems Controls per Jlab Ops technology
- Technical Review of Vendor Supplied Equip Designs

— SNS: Partnership Laboratory, 5 years, 2000-2005

- **Provide Turn Key Cryogenic Integrated 2.1K System**
 - Early Program A+E/Civil Requirement Planning
 - Process Cycle Design and Major Subsystem Equip Purchase
 - Design/Fabricated 2.1K Cold Box
 - Full field installation construction design package
 - Designed Cryogen Distribution System, SNS fabricated
 - Vendor Technical Quality Assurance
 - System Commissioning,
 - Cost Control and Schedule Program Management
- **Continued FY2006 collaboration in support of SNS Cryo OPS**



JLab Designed SNS Plant

Helium Compressor



4K Cold Box



LN2 Storage Dewar



SNS 2K Cold Box



Oil Removal System



Gas Storage Vessels



JLab Cryogenic Collaborations (cont)

- **JLab Collaborations (cont.)**

- **Michigan State University, 1999-2001**

- **Turn Key NSCL Facility 4K System Design**
 - Early Program A+E/Civil Requirement Planning
 - Major Subsystem Specification/Purchase
 - Full field installation construction design package
 - Cryogen Distribution System
 - Vendor Technical Quality Assurance
 - Cost Control and Schedule Program Management
 - Automated Plant Control and Commissioning Support

- **FERMI: SMTF 2K Collaboration, 2005**

- **Jlab provided 2.1K Warm Helium Vacuum System**
 - **Optimal Process Refrigeration Cycle Study**

- **Florida State University, 2005**

- **Approached for JLab/FSU FEL 2.1K cryogenic system design**
 - **Collaboration request for NHMFL Cryo OPS engineering support**



Other Technical Activities

- 2005 Cryogenic Engineering Conference Course for international laboratory and industry organizations, “Design of Optimal Helium Refrigeration and Liquefaction Systems”
- 2005 Cryogenic Engineering Conference Presentation for “Equal Carnot Step” plant design concept
- 2004, JLab initiated and hosted 1st biennial international “Cryogenic Systems Operations Workshop”. Next workshop to be hosted by SLAC, May 2006

